

Fernández and Alonso reply:

Our conclusions [1], about the value of p in the time evolution $m \propto t^p$ of the magnetization, are questioned in Ref. [2]. In order to dispel the suspicion that our Monte Carlo (MC) results may be size dependent, we show in Fig. 1 results for various system sizes, both in SC and FCC lattices, that (1) exhibit that p does depend on lattice structure, as reported in Ref. [1], and (2) show no trace of any size dependence. We find size effects only in smaller systems.

The variation of p with lattice structure should not be perplexing. It is predicted by our theory [3], of which the main result, i.e., Eq. (11) of Ref. [1], is known. Its predictions, given in Ref. [1], are also shown in Fig. 1. Furthermore, for vanishing tunneling window widths, Eq. (11) of Ref. [1] gives [3]

$$\frac{\sin(p\pi)}{p} = \sqrt{2\pi} \frac{\sigma}{h_0} \quad (1)$$

for *all* times well after Γ^{-1} , where σ is approximately the dipole field rms value [3], h_0 is $8\pi^2/3^{5/2}$ times a nearest neighbor dipole field, and Γ^{-1} , as well as all other notation in this Reply, are as defined in Ref. [1]. Values for σ are given in Ref. [3] for various lattices, but, for completeness' sake, we give here $\sigma/h_0 = 0.756, 0.398, 0.417$, and 0.66 for SC, BCC, FCC, and Fe_8 lattices, respectively. Values for p that follow from Eq. (1) agree rather well with the MC results we have reported and with experiments on Fe_8 [4].

So why are the numerical results of the Ref. [2] so different from ours? Ours [1] apply to (1) *annealed* [5] systems, to which a magnetic field H is applied at

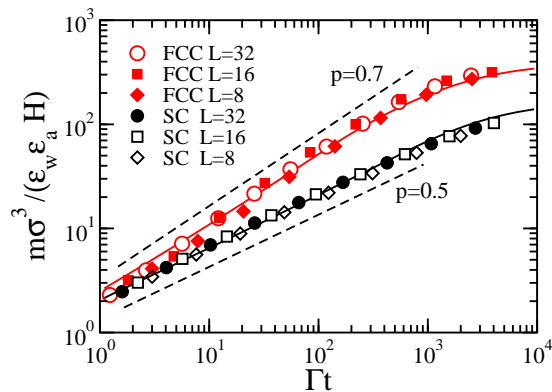


FIG. 1: m , scaled with $\varepsilon_w \varepsilon_a H / \sigma^3$, versus Γt for SC and FCC lattices with $N = L \times L \times L$ and $4 \times L \times L \times L/2$ spins, respectively. All points stand for averages over at least $10^7/N$ MC runs, with $\varepsilon_w = 0.05$, $H = 1$, and $\varepsilon_a = 0.43$ and 0.50 , for SC and FCC lattices, respectively. Full lines stand for theoretical results.

$k_B T \lesssim 0.1U/S$, if (2) $H \ll \sigma$ [such as $H \lesssim 4$ mT and $\sigma \approx 30$ mT (i.e., $g\mu_B S\mu_0 H \lesssim 0.05$ K and $g\mu_B S\mu_0 \sigma \approx 0.4$ K in obvious notation) in Ref. [4]]. Neither of these two conditions is met in Ref [2], where initial spin configurations are random and $H > \sigma$.

Annealing is essential in the magnetization process studied in Ref. [1]. The very nature of the process depends on it. In annealed systems, spin-up and spin-down populations that are able to tunnel, i.e., on sites where dipolar fields approximately cancel H , are unequal, and this drives the magnetization process. In unannealed systems both populations are, on the average, initially equal, and much slower thermal equilibration processes then drive the magnetization evolution [6]. Furthermore, annealing is hard to avoid in experiments such as in Ref. [4]. An Fe_8 crystal held for as little as 1 second within the range $20 \gtrsim T \gtrsim 2$ K before quenching to much lower temperatures, will qualify as annealed [5], and its magnetization will be at least two orders of magnitude larger, for up to minute (roughly $4\Gamma^{-1}$) after $H \ll \sigma$ is applied, than it would have been had the initial spin configuration been somehow completely randomized initially.

Furthermore, the results we have obtained for the magnetization of annealed systems also apply to the relaxation of the magnetization in zero field, after cooling in a *weak* field [3]. Then, $m(0) - m(t) \propto t^p$ while $1 \lesssim \Gamma t$ and $m(t) \gtrsim 0$, and p is also given by Eq. (1).

Incidentally, in unannealed systems (as in Ref. [1]), p is also nonuniversal, varying with H , increasing monotonically as H decreases, up to a value slightly larger than 1 for $H \ll \sigma$.

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- [4] W. Wernsdorfer, T. Ohm, C. Sangregorio, R. Sessoli, D. Mailly, and C. Paulsen, Phys. Rev. Lett. **82**, 3903 (1999).
- [5] By “annealing” we mean a significant amount of thermal equilibration at $T \gtrsim 0.1U/k_B$ and well above the magnetic ordering temperature.
- [6] The magnetization rate in annealed [unannealed] systems goes as ε_w/σ [$(\varepsilon_w/\sigma)^3$], where ε_w is the tunneling window

($\varepsilon_w \sim 10^{-2} \sigma$ in Fe₈); see J. F. Fernández, Phys. Rev. B **66**, 064423 (2002)